8212 OR 2,876,364
250/201

3/6409

March 3, 1959 R. B. GOODY 2,876,364

AUTOMATIC CONTROLS FOR VAPORIZORS

Filed Oct. 23, 1952

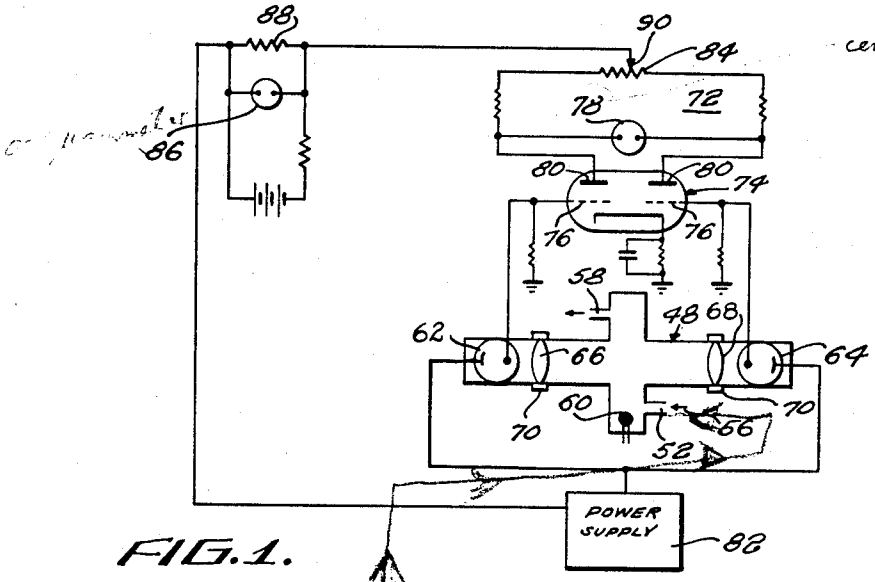


FIG. 1.

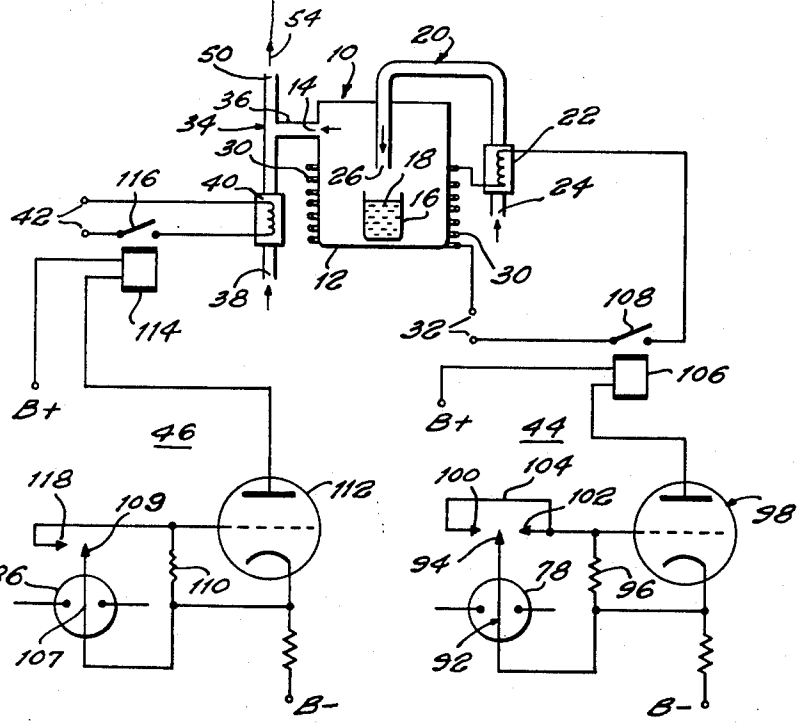


FIG. 2.

INVENTOR.
ROBERT B. GOODY
BY Edwin Lensch +
Harry Cole
ATTORNEYS

United States Patent Office 2,876,364
Patented Mar. 3, 1959

2,876,364

AUTOMATIC CONTROLS FOR VAPORIZERS

Robert B. Goody, River Edge, N. J., assignor to Federal Electric Products Company, Newark, N. J., a corporation of Delaware

Application October 23, 1952, Serial No. 316,409

19 Claims. (Cl. 250—218)

The present invention relates generally to a vaporizer, and in particular to automatic controls for the vaporizer.

In testing the absorption capacity of filter material, it is essential for accurate results that the test medium be constant. For example, in testing filter cannisters, of the type used in gas masks, for determining whether said cannisters have the required degree of filtering action, a fog or smoke consisting of a cloud of fine suspended matter is passed through the cannister. The concentration of said matter at the output of the cannister is compared with the concentration thereof at the input to determine the degree of filtering action. However, for accurate results, especially when comparing the actions of different types of filters, both the size and concentration of the suspended particles of said matter must be maintained constant at the input to the cannister.

Therefore, the primary object of the present invention is the provision of means for providing a cloud of fine suspended matter, wherein both the size and concentration of the particles are maintained at constant predetermined values, respectively.

Another object is the provision of automatic controls for a vaporizer for producing a cloud of fine suspended matter having particles of predetermined size and having a predetermined concentration of said particles.

The above and other objects, features and advantages of the present invention will be more fully understood from the following description considered in connection with the accompanying illustrative drawings.

In the drawings:

Fig. 1 is a more or less diagrammatic illustration of an indicating system, pursuant to the present invention, for indicating variations in both the size and the concentration of the particles in a cloud of suspended matter; and Fig. 2 is a more or less diagrammatic illustration of a vaporizer provided with a control system operable by said indicating system.

Referring now to the drawings in detail, the reference numeral **10** indicates a vaporizer constituted, as here shown, by an enclosed housing or container **12** provided with an outlet opening **14**. A receptacle **16** is provided in the housing and is filled with suitable material **18** for providing a cloud of fine suspended matter when vaporized. The material **18** may be any material which is suitable for the purpose, such as, for example, and not by way of limitation, dioctal pthalate. In order to produce a smoke or fog having particles of said material, heated air is directed onto said material through the air conduit or supply-means **20**. Said conduit is provided, as at **22**, with a suitable electric heating element for heating the air which passes therethrough from the inlet **24** thereof, through the outlet **26** thereof. In addition to heating the air which is directed upon the material in the receptacle **16**, it will be noted that the container **12** is also provided, on the outer surface thereof, with an electric heating coil **30**. As here shown, the coils **22** and **30** are connected in series to a suitable power source, as at **32**. It will be understood that the heated air directed upon the material

18 will produce a fog or smoke comprising a cloud containing particles of said material which will leave the container **12** through the outlet **14** and pass into a conduit **34** having a branch **36** connected to the outlet **14**. The heat of said coils serves to control the particle size. The conduit **34** provides a supply of mixing or quenching air for the fog which leaves the container **12**, and serves to vary the concentration of said particles. The conduit **34** has an air inlet, as at **38**, and is provided with an electric heating element **40** for heating said quench-air. The heating element **40** is connected to a suitable source of power, as at **42**.

From the foregoing, it will be apparent that the vaporizer **10** has three variables which determine the size of the particles, as well as the concentration thereof, in the cloud of suspended matter which passes through the conduit **34**. As herein used, the term "concentration" means the number of micrograms of cloud-forming agents or particles per liter of air, per unit of time, which flow from the conduit **34**. Said variables comprise the following:

(1) The temperature of the material **18**, which is controlled by the heating element **30**.

(2) The temperature of the heated air directed on said material through the conduit **20**, which is controlled by the heating element **22**.

(3) The temperature of the mixing or quenching air in the conduit **34** which is controlled by the heating element **40**.

Pursuant to the present invention, apparatus generally indicated at **44** is provided to automatically control the energization of the heating coils **22** and **30**, and apparatus generally indicated at **46** is provided to automatically control the energization of the heating coil **40**, whereby to automatically control said variables for maintaining both the particle size and the concentration thereof at predetermined values, respectively, as hereinafter described in detail.

From the conduit **34**, the cloud of suspended particles is introduced into an optical column or enclosure **48**. In this connection, it will be understood that the outlet **50** of the conduit **34** is connected to the inlet **52** of the column **48** for the passage of the cloud from conduit **34** into optical column **48**, as indicated by the arrows **54** and **56**. The column is also provided with an outlet **58** from which the cloud flows into the device under test, for example, and not by way of limitation, a gas mask cannister provided with suitable filter means. The column **48** is provided with a suitable light source **60**. In addition, the column is provided with the opposing photo-electric means or photo-multiplier units **62** and **64**. Each photocell unit is provided with an associated polaroid disc or light-polarizing lens **66** and **68**, respectively, which is adjustably positioned within the column **48** by suitable adjusting means **70** for adjustably rotating the lens about its axis. It will be understood that each lens is so dispositioned relative to its companion photo-cell, that the only light which the photo-cell receives, is light which passes through the lens.

With the output from the conduit **34** entering the optical column **48**, at **52**, and emerging therefrom at **58**, light rays from the light source **60**, will strike the particles suspended in the cloud or fog and will scatter, pursuant to the well-known "Tyndall Effect." This results in the polarization of the light, the degree of polarization being dependent upon the particle size. The greater the particle size, the greater the rotation of the plane of polarization relative to the axis of travel of the light from the source **60**. Said scattered and polarized light passes through the polaroid lenses **66** and **68**, and serves to energize the companion photo-cells **62** and **64**, respectively. It will be understood that the lenses **66** and **68** are

initially adjusted to provide for maximum passage of light therethrough for a predetermined particle size, for example, a particle size of 29 microns. Therefore, it will be understood that the amount or quantity of light which is passed to the photo-cells will change with the degree or angle of polarization, and further that said degree or angle of polarization will change with particle size in the optical cylinder 48.

The output of each of the photo-cells is fed to a balancing circuit generally indicated at 72. As here shown, said circuit is constituted by a double-triode tube 74, each control grid 76 of which receives the output from one of the photo-multiplier units. A micro-ammeter 78 is connected across the anodes 80—80 of said tube so as to respond to changes in the quantity of light reaching said photo-multiplier tubes. It will be understood that the micro-ammeter 78 is provided with a zero centered scale so as to provide an indication on each side of zero for an unbalanced condition in the quantity of light which reaches each of the photo-multiplier units. Further it will be understood that the polarized filter lenses 66 and 68 are initially adjusted to provide for a balanced output of the tube 74 so that the meter 78 is initially set at a zero indication to indicate said balanced condition. A power supply, indicated at 82, provides for the anode voltages of the tube 74 as well as for the dynode voltages for the photo-multiplier units. The anode current flow from each anode of the tube passes through the resistor 84 whereby it will be apparent that the total current representative of the balanced condition in the circuit of the tube 74 will flow through said resistor 84. In order to provide an indication or measurement of said total current flowing through the resistor 84, provision is made for the micro-ammeter 86 which is connected across the resistor 88, the latter having one end connected to the resistor 84 through the tap 90 and the other end thereof being connected to the power supply 82. The micro-ammeter 86 has a scale which registers from zero to a predetermined maximum and is preferably not of the zero centered type, as in the meter 78. Therefore, it will be understood that the meter 86 provides a measurement of the total output of each of the photo-multiplier units and therefore indicates the general level of illumination of said photo-multipliers and is practically independent of the percentage or degree of unbalance which may exist in the amount of light which reaches each of the photo-multipliers. Consequently, the meter 86 provides an indication of the amount or density of the cloud, smoke or fog in the optical column 48, which density is representative of the concentration of the particles since it is directly related to the number of micrograms of smoke forming agents or particles per liter of air. The meter 78 provides an indication of the particle size of said smoke-forming agents by virtue of the fact that there is a direct relationship between the angle of scattering light and particle size, that is, the angle through which the plane of polarization is rotated. This is due to the fact that the degree of change in said angle of polarization is directly related to the particle size. Consequently, it will be readily apparent that the combination of the meters 78 and 86 gives complete information relative to the smoke which is passing through the optical cylinder 48, the meter 78 indicating larger or smaller variations in the particle size, and the meter 86 indicating variations in the concentration of the smoke-forming agents.

Pursuant to the present invention, the meter indications are utilized to control the previously mentioned variables. Referring now to Fig. 2, the indicator for the zero centered-meter 78 is illustrated at 92. At one end thereof, said indicator is provided with a contact 94, and at the other end thereof it is in circuit with the control grid resistor 96 of the tube 98. Provision is also made for the companion contacts 100 and 102 which are interconnected by the wire 104. It will be noted that the relay 106, in the plate circuit of the vacuum tube 98, controls the energization of the heating elements 22 and 30 by opening or closing the circuit thereof, as at 108. It will be understood that the normal plate current flow through the tube 98 is insufficient to energize the relay 106 for closing the circuit of the heating elements 22 and 30, at 108. With all the particles of a predetermined desired size, as previously indicated, and with the lenses 66 and 68 and the meter 78 properly adjusted, there will be a balanced condition in the circuit 72, so that the indicator 94 will be at zero on the scale of said meter. Assuming now that the particle size changes from the desired size, there will be an unbalanced condition in the circuit 72 so that the indicator 92 will deflect, either to the right or to the left, from the centered position thereof, dependent upon the degree and the direction of the unbalance. Upon said unbalance, the contact 94 of the indicator 92 will engage with either the contact 100 or the contact 102, as the case may be, said latter contacts being disposed at the same distance on either side of the zero indication. For example, a deflection of 5 micro-amperes on either side of zero on the meter 78 will effect engagement of the contact 94 with one of the contacts 100 or 102, whereby to short-circuit the grid resistor 96 to increase the current flow through the plate circuit of the tube 98, whereby to energize the relay 106 sufficiently to close the circuit for the heating elements 22 and 30 at 108. Said heaters will then operate to heat the liquid 18, as well as the air which is directed upon said liquid through the conduit 20, until the particles return to the desired predetermined size. Thereupon, the indicator 94 will return to its zero position, for the balanced condition of the circuit 72, and open the circuit of said heating coils.

The meter 86 is provided with an indicator 107 having the contact 109 at one end thereof, and connected at the other end thereof to the grid resistor 110 of the vacuum tube 112. A relay 114 in the plate circuit of the tube 112 controls the energization of the heating element 40, as at 116. It will be understood that the normal current flow through the vacuum tube 112 is insufficient to energize the relay 114 to close said circuit at 116. A contact 118 is disposed for engagement by the indicator contact 109. Assuming now that the meter 86 is set to show a reading, for example, of 20 micro-amperes for a predetermined concentration of particles in the optical column 48, it will be understood that the contact 118 is so positioned as to be engaged by the contact 109 when the latter is deflected to a lesser indication, for example, of 19 micro-amperes. Therefore, it will be apparent that if the particle concentration drops below the desired level, the contacts 109 and 118 will engage to short-circuit the grid resistor 110 whereby to close the circuit for the heating element 40, at 116, so as to heat the quenching air through the conduit 34 until the indicator 107 disengages the contact 118.

From the foregoing it will be readily apparent that the meter 78, which indicates variations in the particle size, is utilized in a control circuit for maintaining said particle size at the predetermined size thereof. Similarly, the meter 86, which is utilized to indicate variation in the concentration of the particles, is utilized to control a circuit for maintaining said concentration at a predetermined desired level.

While I have shown and described the preferred embodiments of my invention, it will be understood that various changes may be made in the present invention without departing from the underlying idea or principles of the invention within the scope of the appended claims.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. In apparatus of the character described, at least a pair of photo-electric means disposed to be energized by light rays scattered and polarized by the particles in a cloud of suspended matter, means responsive to the out-

put differential of said pair for indicating variation in the size of said particles from a predetermined size thereof, and means responsive to the total output of said pair for indicating variation in the concentration of said particles from a predetermined concentration thereof.

2. In apparatus of the character described, at least a pair of photo-electric means disposed to be energized by light rays scattered and polarized by the particles in a cloud of suspended matter, means responsive to the output differential of said pair for indicating variation in the size of said particles from a predetermined size thereof, and means responsive to the total output of said pair for indicating variation in the concentration of said particles from a predetermined concentration thereof, said pair being disposed in opposition.

3. In apparatus of the character described, at least a pair of photo-electric means disposed to be energized by light rays scattered and polarized by the particles in a cloud of suspended matter, means responsive to the output differential of said pair for indicating variation in the size of said particles from a predetermined size thereof, means responsive to the total output of said pair for indicating variation in the concentration of said particles from a predetermined concentration thereof, and means for subjecting a cloud of suspended matter to a light source for polarizing the light rays intercepted by particles thereof, said last mentioned means including an optical column, said pair being disposed in opposition therein, a source for directing light transversely of a line extending between said pair, and said columns having cloud inlet and outlet means disposed to effect a flow of said particles transversely of said line and between said pair.

4. In apparatus of the character described, means for generating a cloud of suspended matter, said generating means having means operable to vary both the particle size of said matter and the concentration thereof, and means for automatically controlling the operation of said varying means, whereby to maintain said particle size and said concentration substantially constant, said last mentioned means comprising at least a pair of photo-electric means disposed to receive light rays scattered by the particles, means responsive to the output differential of said pair for controlling the particle size varying means, and means responsive to the total output of said pair for controlling the concentration varying means.

5. In apparatus of the character described, a vaporizer adapted to contain a supply of material to be vaporized, said vaporizer having heated-air supply means directed upon the material for generating therefrom a cloud of suspended matter and a heated quench-air supply means for mixing with said cloud, and means automatically operable to vary the temperatures of said air supplies, respectively, whereby to control both the concentration and the particle size of said cloud.

6. In apparatus of the character described, a vaporizer adapted to contain a supply of material to be vaporized, said vaporizer having heated-air supply means directed upon the material for generating therefrom a cloud of suspended matter and a heated quench-air supply means for mixing with said cloud, and means automatically operable to vary the temperatures of said air supplies, respectively, whereby to control both the concentration and the particle size of said cloud, said last mentioned means comprising at least a pair of photo-electric means disposed to receive light rays scattered by the particles of said cloud, means responsive to the output differential of said pair for controlling the heating of said first mentioned air-supply, and means responsive to the total output of said pair for controlling the heating of said other air-supply means.

7. Apparatus as defined in claim 5, further characterized in the provision of heating means for said vaporizer, said automatically operable means being effective to control said heating means.

8. Apparatus as defined in claim 6, further characterized in the provision of heating means for said vaporizer, said heating means being operable under the control of said output differential.

9. In apparatus of the character described, a vaporizer adapted to contain a supply of material to be vaporized, said vaporizer having air-supply means directed upon the material for generating therefrom a cloud of suspended matter and a quench-air supply means for mixing with said cloud, a heating element for each of said air-supply means, and means automatically operable to control the energization of said heating elements, respectively, whereby to control both the concentration and the particle size of said cloud.

10. Apparatus as defined in claim 9, further characterized in the provision of a heating element for said vaporizer, said control means being operable to control the energization of said last-mentioned heating element.

11. In apparatus of the character described, means for subjecting a dispersion of suspended particles to a beam of light for polarizing the light rays intercepted and scattered by said particles, a pair of photo-electric means disposed in opposition for energization by the polarized light, a variable polarizing means associated with each of said photo-electric means for transmitting thereto polarized light having a predetermined angle of polarization corresponding to a predetermined particle size, whereby to provide for a predetermined energization of said photo-electric means for said predetermined particle size, and means responsive to the total output of said photo-electric means for indicating the concentration of the particles.

12. In apparatus of the character described, means for subjecting a dispersion of suspended particles to a beam of light for polarizing the light rays intercepted and scattered by said particles, a pair of photo-electric means disposed in opposition for energization by the polarized light, a variable polarizing means associated with each of said photo-electric means for transmitting thereto polarized light having a predetermined angle of polarization corresponding to a predetermined particle size, whereby to provide for a predetermined energization of said photo-electric means for said predetermined particle size, means responsive to the differential output of said photo-electric means for indicating a variation in the size of said particles from said predetermined size and means responsive to the total output of said photo-electric means for indicating the concentration of the particles.

13. Apparatus as defined in claim 12, further characterized in that said ouput differential means includes a circuit for balancing the current outputs of said pair for said predetermined particle size, a meter in said circuit to indicate the current differential of said outputs as a function of variation in particle size from said predetermined particle size, and an additional meter connected to indicate the total current in said circuit as a function of particle concentration.

14. In apparatus of the character described, means for subjecting a cloud of suspended particles to a beam of light for polarizing the light rays intercepted by said particles, and means responsive to the polarized light for indicating the concentration of said particles in said cloud, said means including a pair of photo-electric means each provided with a respective polarized filter device arranged to receive light from the particles substantially perpendicular to the path of the light beam and at opposite sides thereof, respectively, and means deriving the differential between the output of said photo-electric means for indicating the size of particles in the cloud.

15. Apparatus in accordance with claim 14, including means for additionally deriving the combined output of said pair of photoelectric means for indicating the concentration of particles in the cloud.

16. In apparatus of the character described, means for subjecting a cloud of suspended particles to a beam of light causing the light rays intercepted by the particles

to be scattered and polarized, a pair of photocells each having a polarized light filter spaced apart and disposed laterally of the beam of light to which the cloud is subjected, and means responsive to the differential output of the photocells for indicating the size of particles in said cloud.

17. In apparatus of the character described, means for subjecting a cloud of suspended particles to a beam of light causing the light rays intercepted by the particles to be scattered and polarized, a pair of photocells each having a polarized light filter spaced apart and disposed laterally of the beam of light to which the cloud is subjected, and separate means responsive both said photocells for separately indicating the size of the particles and the concentration thereof in said cloud.

18. In apparatus of the character described, means for generating a dispersion of suspended particles including control means for varying the size of the particles in the dispersion, means for subjecting the particles to a beam of light that is scattered and polarized by the particles, a pair of photocells each having a polarized light filter spaced apart and positioned laterally of said light beam, and means for deriving the differential output of said photocells, said last-named means being in control relation to said control means for maintaining the particle size substantially constant.

19. In apparatus of the character described, means for generating a dispersion of suspended particles including control means for varying the size and concentration of particles in the dispersion, a pair of photocells each having a polarized light filter spaced apart and positioned laterally of said light beam, and means for separately deriving both the total output and the differential output of said photocells, said last-named means being in control relation to the control means of said dispersion generating means for separately maintaining the concentration of the particles and the size of the particles substantially constant.

References Cited in the file of this patent

UNITED STATES PATENTS

2,244,362	Hartig	June 3, 1941
2,436,262	Miller	Feb. 17, 1948
2,437,963	Langmuir	Mar. 16, 1948
2,494,441	Hillier	Jan. 10, 1950
2,510,977	Hobelmann	June 13, 1950
2,562,181	Frommer	July 31, 1951

OTHER REFERENCES

"The Principles of Optics," by A. C. Hardy and F. H. Perrin, 1st Ed., McGraw-Hill, 1932; page 604, section 214.